An Accident Detection System on Highway through CCTV with Calogero-Moser System

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Abstract

There are many limits such as shadowing occlusion and no lights in the video image detector systems. In order to make accurate detector system, we need to get rid of these problems specially accident detection system by using vehicle trace. In this paper, we introduce a method to overcome shadow and nighttime has been introduced as well as the accurate accident detection system. We find the flow of vehicle trace is such as level spacing distribution as Wigner distribution. It is in the level statistics when the vehicle trace is avoidable. From this distribution we can derive a probability induced by different of position for each lane. Using this equation we can find abrupt state of vehicle flow comparing with normal flow. We shall show statistical results from some experiments for this system evaluation.

Keywords

Accident Detection System; Detection Abrupt Signal; Calogero-Moser System

Introduction

The goal of a traffic monitoring system is to extract traffic information, such as the vehicle volume count, traffic events, and traffic flow, which plays an important role in traffic analysis and traffic management[1]. In these extracting information, the occlusions have taken place when two or more vehicles and shadows are regarded as one vehicle because of overlapping from the viewpoint of camera. There is explicit occlusion or implicit occlusion and the explicit case can be detected easier than implicit case because of identifying individual vehicles before occlusion. The shadows which is explicit case can cause various unwanted behavior such as object shape distortion and merging, affecting surveillance capability like target counting and identification[4].

Generally, image processing and object tracking techniques have been mostly applied to traffic video analysis to address queue detection, vehicle classification, and volume counting[5,6]. In this case, Model-Based tracking is highly accurate for a small number of vehicles[7].

If the number of vehicle is increasing, we need new background model such as the Kalman-filter-based adaptive background model, because the background changes rapidly. In this situation, if a separate contour could be initialized for each vehicle, then each one could be tracked even in the presence of partial occlusion[2,8]. There are three types occlusions, that is track occlusions, background object occlusions and apparent occlusions[10].

In track occlusions, in order to resolve more complex structures in the track lattice, the bounding box tracking is used by appearance based modeling[9]. The appearance model is an RGB color model with probability mask similar to that used by Ismail Haritaoglu et. Al[11]. In methods to solve the implicit occlusion problem in moving objects, the fusions of multiple camera inputs are used to overcome occlusion in multiple object tracking[12]. The Predictive Trajectory Merge-and-Split (PTMS) is proposed to uses a multi stage approach to determining the vehicle motion trajectories and eventually the lane geometry[13,14]. Some shadow elimination techniques have been classified in the literature into two groups, model-based and property-based technique[14]. The shadow removal approaches are based on an assumption that the shadow pixels have the same chrominance as the background but lower luminance[4,15]. The earliest investigations in shadow removal proposed by Scanlan et. Al[16]., the image was split into square blocks and produced an image based on the mean intensity of each block. It os kown that the vision-based with nighttime images is RACCOON system[17] which has been integrated into a car experiment on the CMU Navlab II, tracks car taillights. Also, another pattern classifier algorithm is Support Vector Tracking (SVT) which integrates the SVM classifier into optic-flow based on tracker[18]. The bright regions in the nighttime generated by

headlights, tail lights, break lights, and reflected lights around light sources are recognized as the vehicle feature. Because of above things, in this paper, we use an advanced shadow elimination techniques for preventing occlusions, so we develop an accuracy of finding traffic information. In addition to this system, we use the vehicle trajectories for traffic accident detection system, accordingly identifying lane change patterns from the camera's field of view[2,3]. In this case, the flow of vehicle trace is like as level spacing distribution as Wigner distribution in the level statistics when the vehicle trace is avoidable. From this distribution we can derive a probability induced by different of position for each lane. Using this equation we can find abrupt state of vehicle flow comparing with normal flow. For this system evaluation, we shall show statistical results from some experiments. In section 2, we introduce an advanced shadow elimination technologies. In section 3, the detection method of abrupt signal is introduced on Wigner distribution.

Adavanced Shadow Elimination Techiques

We explain the basic idea behind the tracking algorithm developed in this research. Vehicle tracking has been based on the region-based tracking approach. For individual vehicle tracking the first step, In order to extract the vehicle exactly. In the second step, we have conducted the background subtraction, deciding threshold for binary images. The background subtraction algorithm requires a relatively small computation time and shows the robust detection in good illumination conditions[19]. In the third step, morphology for small particles removal as noise, sets in mathematical morphology represent the shapes of objects in an image, for example, the set of all white pixels in a binary image is a complete description of the image. In the next step, it is important to remove cast shadows due to the the vehicle are was extracted exactly and a new algorithm was developed in this paper using edge detection and vertical projections within the vehicle particles. And the fifth step generates the vehicle ID and labeling to each vehicle, and individual vehicle's bounding rectangle data, i.e., left, top, right, bottom coordinates. These particle data are saved into reference table which can be referred to next sequence frames. In this system, the occlusion detection is easy relatively because of short length of detection zones, less than 15m. The consideration is only limited to explicit occlusion. The explicit occlusion cases have taken place several times during the field test, that is, multiple vehicles enter a scene separately into detection zone, and merge into a moving object region in the scene. In this case, we have maintained each vehicle ID continuously as referred to previous frame.

In the nighttime, diffused reflections on the road due to vehicle headlights pose a serious concern. Thus we need to pre-processing by reflection elimination to adjust the light parameters such as luminosity or brightness, contrast, intensity. In order to extract the vehicle exactly, we have to consider about background estimation, occlusion, cast shadow detection and elimination, and light condition processing at night.

Our system has covered the four lanes with single camera. As the more system has to be processed, the less performance of system has been. The reason for that if we have included the implicit occlusion process, the performance evaluation marked low grade especially the calculation of velocity. The occlusion detection of this system is easy relatively because of short length of detection zones, less than 15m.

Many algorithms of cast shadow elimination are proposed, the various cases occurre in the real traffic flows, for example, dark or light shadows, shadow from trees or clouds.

The proposed algorithms as mentioned before, have been applied to our experiment, the shadows cannot be extracted exactly as a result.

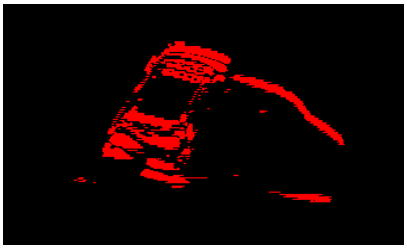
Thus we have developed the appropriate algorithm in our test site. The basic concept is that the shadow area has less edge because of no variance within shadow. On the other hand, vehicle area has more edges relatively. Let B be a binary image plane and B_x be a set of number of vertical pixels which value is 1 at x. We define a function $Verti : B/x \to B_x$

$$by\ Verti\ (x) = \sum_y B_1(x, y) \ , \qquad (1)$$

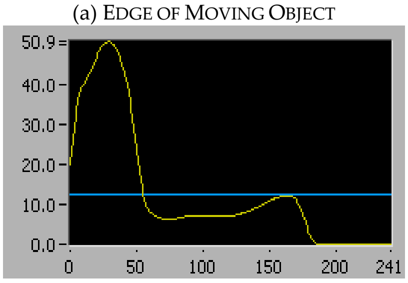
where $B_1(x, y)$ is a pixel of which value is 1 at (x, y) and B/x is a projection of B into x. In Figure 1b, the distribution of edges from moving object area can be discriminated between vehicle and cast shadow. And then discard under 25%, that is cast shadow area, Figure 1b.

The light condition is a lot different from whether streetlamps are on the road or not. The around road with streetlamps has a bright under night, whereas around the vehicle headlight can be classified

distinctly without streetlamp. In the test site has no streetlamp. Diffused reflections on the road due to vehicle headlights pose a serious concern during the night processing even though there is no streetlamp. Thus we need reflection elimination to adjust the light properties such as luminosity or brightness, contrast, intensity. We have adjusted the luminosity in this test in order to eliminate the diffused reflections on the road. Then, vehicle detection can be achieved through the detection of headlight by grey value shown in Figure 2.

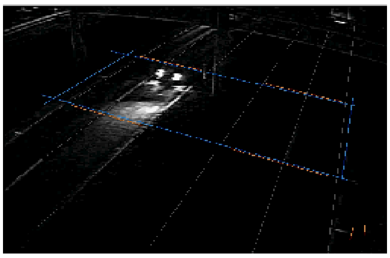


(a) EDGE OF MOVING OBJECT

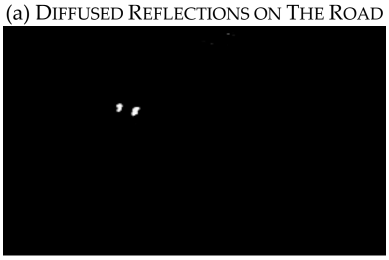


(b) SHADOW AREA UNDER BLUE LINE, 25%

FIG. 1 CAST SHADOW DETECTION PROCESS IN OUR TEST SITE



(a) DIFFUSED REFLECTIONS ON THE ROAD



(b) ADJUST THE LUMINOSITY IN THIS TEST DUE TO VEHICLE HEADLIGHTS

FIG. 2 DIFFUSED REFLECTION ELIMINATION DURING THE NIGHT

Detection of Abrupt Signal on Wigner Level Spacing Distribution

The flow of vehicle can be represented by trajectories, and a time series can be figured from this trace when the flow of vehicle volume is calculated for some time interval at each lane as Figure 3.

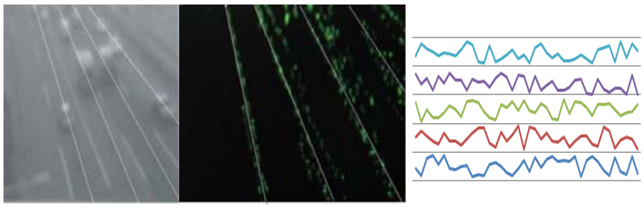


FIG. 3 TRAJECTORIES OF VEHICLE AND IT'S TIME SERIES FOR EACH LANE

The distribution of position from the bottom line is Wigner distribution (2) in this time series as Figure 4.

$$P(S)=\frac{\pi}{2}S\exp(-\frac{\pi}{4}S^2) \quad (2)$$

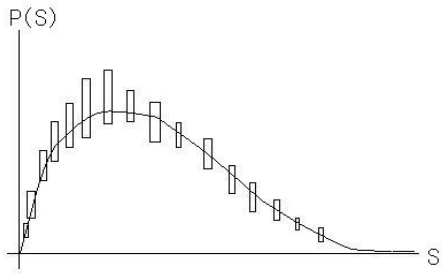
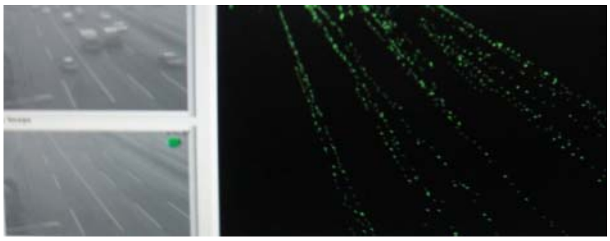


FIG. 4 WIGNER DISTRIBUTION OF TIME SERIES

If the Generalized Calogero-Moser system is applied to this equation (2) after finding the eigenvalue of Hamiltonian, we can get the equation (3).

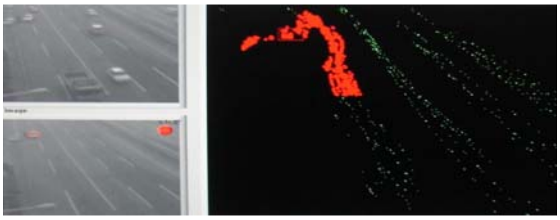
$$p(x_1,x_2,...,x_n)=C\prod_{1\le i,j\le n}|x_i-x_j|^{v} \quad (3)$$

Where x_i is position value of each lane. This equation (3) has maximum value when vehicle flow is same for every time at each lane for example each vehicle flow is same. But if one or two lane has no vehicle flow except other lane has normal flow, the value of equation (3) is abruptly changed. So, the detection system can be made by checking the value of (3) which is abrupt value compared with previous value for some time. In this case we can choose C, v properly for accurate precession and time interval to decision abrupt.



(a) VEHICLE TRACE HAS NO CHANGE

(b) VEHICLE TRACE IS CHANGED



(c) VEHICLE TRACE IS CHANGED AGAIN

FIG. 5 SHOWING IMAGES FROM NORMAL FLOW TO ABRUPT FLOW AND WARNING STATE

Since, as in Figure 5. , we can find some change of trace image (b) (c) and need to calculate abrupt signal, after that, delivering warning to manager when the calculated abrupt signal image like as Figure 6, in this case C, v handle the height of $P(S)$. If C increases, the noise increases and if v increases, ther is no comparative degree normal state and abrupt state did not distinguished.

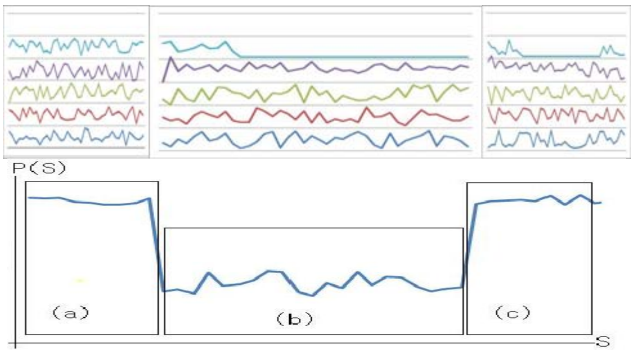


FIG. 6 (a) IS AN AREA OF NORMAL VEHICLE FLOW SIGNAL, (b) IS AN AREA OF ONE LANE FLOW IS STOPPED AND (c) IS AN DETOUR AREA OF FLOW

Experimental Results

The traffic information can be obtained by aggregating count vehicles passing through the detection zones for one minute. The more detailed measuring results, which are compared with aggregating one minute of baseline data and measuring volume counts for 30 minutes within each time period, are illustrated in Figure 7. as followings.

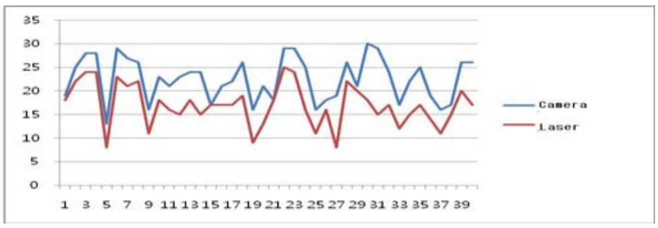


FIG. 7 VOLUME COUNTS FOR 30 MINUTES WITHIN EACH TIME PERIOD

For evaluating accident detection system, the experiments were carried out from stored moving image, because accident image is not easy searched, in this case detection time interval is changed per each experiments as shown 10 case in Table 1.

TABLE 1 EXPERIMENTAL RESULTS BY CHANGING DETECTION TIME WHERE "o" IS DETECTED CASE "x" IS MISSED CASE

Case / Time	1	2	3	4	5	6	7	8	9	0
0.5min	x	x	x	x	o	o	x	o	o	o
1min	o	o	o	o	o	o	o	o	o	o
1.5min	o	o	o	o	o	o	o	o	o	o
2min	o	x	o	o	x	o	x	o	x	x

From this data we take two values as $C = 2.3, \; v = 1.2$ is properly good as in Figure 8.

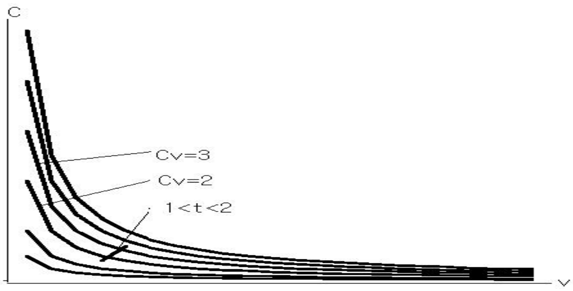


FIG. 8 WHEN $1 \le t \le 2$, $2 \le Cv \le 3$ INDUCED FROM EXPERIMENTAL DATA

Conclusions

There are two issues, one of which is overcoming occlusion by shadow and the other is accident detection system in this paper. The two issues are strictly related occlusion disturbs make accident detection system accurate. In order to eliminate shadow, we have developed the new algorithm using analysis of edge distribution of vehicle and shadows. If the shadow was not erased, the volume for each lane won't be calculated correctly, accordingly the accident detection is not accurate. In here, we have known the flow of vehicle trace has Wigner distribution in the level statistics when we represent each trace avoidable. From this distribution a probability was derived by representing different of position for each lane. Using this equation we could find abrupt state of vehicle flow comparing with normal flow. In this situation, the detection time interval was experimentally good for 1-1.5minutes. In future works, we shall calculate the optimized detection time interval for every accident on high way.

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